

THE MAIN CAUSES OF ACTIVATION TWO LARGE LANDSLIDES OF THE DEBED RIVER GORGE IN XXI CENTURY

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Summary: Specialists have estimated about 3000-3500 active landslides in the territory of the Republic of Armenia, which occupy 8-10% of the territory and threaten 15% of the population of the Republic of Armenia. The average annual damage to them is about \$10-30 million. There are two major landslides in the 21st century, located in the Deved river gorge, threatening the only functioning railway connecting Armenia to Georgia, one of the main highways. One of them is the landslide-collapse of Ayrum, which suddenly became active in 2011 and took the lives of 5 people and caused huge material losses. A large part of the railway was destroyed and the highway became impassable. The second landslide, which became active in 2018 was near the town of Tumanyan. Here, a huge number of stones were moved, landslide tongue was approached to the transport infrastructure, which posed a serious threat to the republic. Our on-site studies have shown that the causes of both landslides are a result of anthropogenic impact. The article suggests specific measures to prevent landslides.

Key Words: Landslide, activation, lifelines, anthropogenic impact.

Introduction

There are about 3000-3500 active landslides in the territory of the Republic of Armenia, which occupy 8-10% of the territory of the republic. In addition, 15% of the population of Armenia (about 470000 people) live in landslide-prone areas. The direct damage caused by landslides averages \$ 10-30 million a year. Therefore, landslides are one of the major natural disasters in the country after the earthquake [1-2; 4]. In 02.10.2011 a landslide near Ayrum (Bagratashen) killed 5 people, targeted 35 cars, and closed the railway to Georgia for a long time. According to the expert opinion, the analysis of the aerial photographs of 1947, 1975 and 2006 shows that until 01.10. 2011 there was no sign of landslide activation. This landslide was not registered as active landslides in the territory of the Republic of Armenia in the database. The other, Tumanyan's landslide, which was known to experts because it was active several times in the twentieth century, moved sharply on January 12, 2018. He threatened to close the railway and the highway, due to which a very disturbing situation was created in the republic. Fortunately, it stabilized when the inflow of water to the landslide body was stopped.

The authors of this article have studied both of these landslides on the spot and submitted a conclusion to the RA Ministry of Emergency Situations on the reasons for their structure and activation. Let us briefly present the structural features of these two landslides and the main reasons for their activation.

Ayrum (Bagratashen) landslide-collapses of 02.10.2011

This is a landslide-collapse, because there are elements that characterize both the landslide and the collapse. The landslide-collapse body is mainly represented by low-strength loess soils with a visible capacity of up to 30 m. There is also a small amount of coarse-grained soils. Prior to the landslide, most of the area was covered with basalts up to 7 m thick (Fig. 1). One of the main features of loess soils is the significant loss of strength when moisturizing and dynamic impacts. At present, any intervention on the landslide-body is fraught with a new movement of the masses.



Fig. 1. Overview of Ayrum landslide-collapse area (the basalt cover is destroyed). On the site, above the collapse, the ground is water-saturated, wetlands.

The situation in the area adjacent to the landslide-collapse head. No noticeable cracks or other deformations were found in this area due to the presence of basalt cover. In the southern part of the landslide there is groundwater outlet, and above (on the platform) there are irrigated lands and swamps with an area of 500 m², including reeds. This indicates of the additional moisture of. The area above the landslide is unstable. Only large-scale collapses are possible here, due to basalt cover.

Possible causes of landslide-collapses. The slope was in the ultimate stress (stable) state before the landslide occurred. Any additional effects could lead to loss of stability. One of these additional effects, was the September 27 earthquake in Dmanisi (Georgia), with a intensity of 5-6 point by EMS-98 (M=4.4), which had a intensity of 3-4 in the study area. Were it not for the earthquake and heavy equipment on the highway, it would still be in the future landslide zone. In other words, the impact of the earthquake and heavy equipment could not be the cause of the landslide; they just contributed to its activation.

Conclusions: 1. Cause of landslide-collapse is the long-term wind blowing of the slope, ultimate stress state and additional moistening of loess soils. The impact of the earthquake and heavy equipment were factors contributing to the activation of landslide-collapse; 2. The landslide body is currently in a very unstable state, any intervention can lead to new movements of the masses; 3. Given the situation, the best decision is to build a new, landslide-bypassing highway. Unpredictable consequences are possible on the restored road due to the presence of weak loess soils.

Tumanyan landslide 12.01.2018

General brief description of the landslide. The landslide is located in against of Tumanyan community of Lori region, in the area directly adjacent to the railway on the left bank of the Devbet river. Man-made factors also take place here; these are mainly construction and operation of the water line serving the brick factory (especially the pool that extinguishes the water pressure). The outline of the landslide body is clearly visible in the satellite photos taken 10 years ago (Fig. 2).

Its activation in the past is evidenced by the deformations of the surface of the earth preserved in the area, the presence of reinforced concrete rappers previously installed to control movements, references by locals, etc. The landslide was particularly active in 1955, 1988-1989. The experts considered the reason for the two activations to be the outflow of water from the water pipe coming from the upper plateau, the feeding of the landslide body with that water.

Peculiarities of landslide structure. The landslide is located on the northern denudation slope of Lori deep gorge. Here various deluvial formations cover the radical volcanic basalts. Slope and landslide body soils are represented by loam with various debris content. Often the volume of fragments increases and the soils

according to the classification become large grains with the content of stones. Groundwater is practically non-existent, there is no fixed groundwater horizon. The landslide body stretches up to 320 m and has more than 3 hectares area (32500 m^2 area and about 35000 m^3 volume). Among the features of the landslide it is necessary to mention: a) almost the entire surface of the landslide body, except for the collapse site on the tongue, is represented by a thickness of 4 m, with solid or semi-solid ground crust; b) the basalt foundations of the landslide body have protrusions and grooves that cross the landslide slide surface (Fig.2; Fig.3); c) surface water has no significant effect: d) within the collapsed tongue of the landslide, rapid discharge of accumulated water is observed.

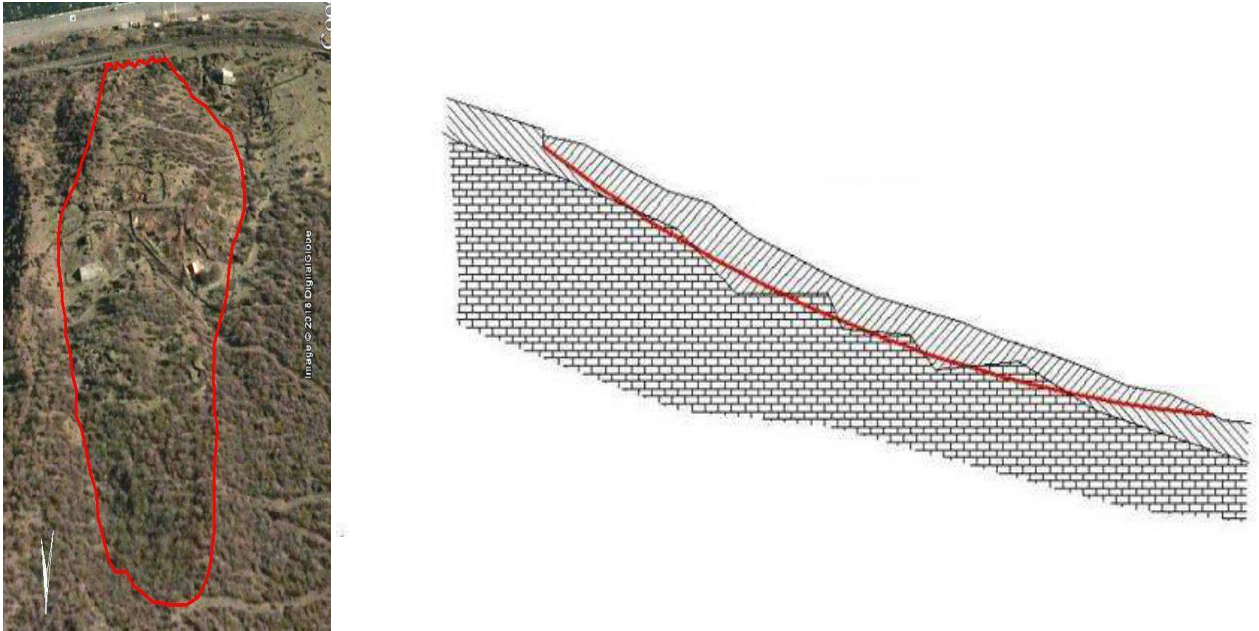


Fig. 2. General view Tumanyan landslide on satellite image and schematic section of the landslide area.



Fig. 3. The view of the Tumanyan landslide (the threat of a displaced mass on the rail) and the crack at the top, on which beacons are placed to record the movements.

The situation in the landslide zone. As of January 13, 2018, the landslide had stabilized as the flow of water through the pipeline was stopped. The possible proofs of this are: a) 1955 u 1988-1989 after activation, when the flow of water from the pipeline to the landslide body was eliminated, the movement of the landslide stopped; b) this time, when the operation of the water line was stopped, the landslide was stabilized; c) the volume of water flowing out of the landslide site near the railway has significantly decreased. In 2018 the displacements caused by the landslide were smaller than the previous ones. Thus, if the horizontal displacements due to the observed activation in the fracture cracks up to 3-4 m depth are 30-50 cm, then they have previously reached meters. The difference between the amplitudes of the old and new vertical displacements at the head of the landslide is obvious. Old, 1989 the vertical drop amplitude of the resulting fault is at least 1.5 m, and in the new fault 0.3-0.4 m.

Conclusions: The cause of all three landslide activations is man-made and was due to water pipe accidents and water penetration into the landslide body. Due to the large mass of the landslide body, the known methods of stabilizing it (construction of a retaining wall, installation of pile, etc.) are not effective. In this situation, the only correct approach to the landslide body is to stop the entry of water, which has already been done.

Landslide has stabilized and abrupt and large-scale activation is possible if strong earthquake with intensity 7 point by EMS-98 occur in this area [3, 5].

Results and discussion:

1. Activation of the two major landslides observed is the result of anthropogenic impact. They would not be activated if there was no water in the landslide bodies.
2. Based on the importance of the Vanadzor-Ayrum railway and highway for the republic, is necessary through specialized organizations, at least visually investigate the presence of landslides and rocky belts along the entire length of the mentioned lines and assess the probability of their activation, depending on man-made and seismic reasons.

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